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Multi–Mineral Block Formulation and Production Using Locally Available Feed Ingredients in Semi – Arid Region of Nigeria

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Abstract : *This experiment was conducted at the University of Maiduguri Teaching and Research farm to evaluate the nutrient composition, production cost, physical characteristics and rumen degradation pattern of multi-mineral blocks used in ruminant feeding in the semi-arid region of Nigeria. Five (5) Multi-mineral blocks were developed (F1 - F5), each containing different proportion of potash, wood ash, eggshell, salt and locust bean pulp (daurawa). 5g of each formulated multi-mineral block was incubated in the rumen of a bull for degradation study at 6, 12, 18, 24, 36, 48, and 72 hours. The rumen degradability value obtained in all the multi-mineral blocks were generally above 60% at 48 hours and ranged from 77.50% - 82.57%. Thus, there is significant (P<0.05) difference in mean degradation of all the multi-mineral blocks while the proximate composition revealed that highest %DM, %CP, %CF, were 95.60%, 1.48%, 22.60%, in F3, F1, F3 respectively and no (P>0.05) effect of formulation on the %EE while F5 had highest 13.00 %ash. Cost of producing a block ranged from ₦ 93 – ₦ 140 equivalents to $0.57 – $0.85 USD. Hence, animals augmented with multi-mineral blocks in their feeding regimen can have better nutrient utilization capacity and good rumen dry matter degradation at a price affordable by smallholder farmers in the study area.*

Key words: *Augment, Daurawa (Locust bean pulp), Formulation, Multi-mineral block, Production cost, Rumen degradation*

I. Introduction

Multi-mineral blocks are hard, stone-like blocks scattered around the animal farm for animals to lick which contain a range of mineral elements to supplement the basic mineral need of the animals. The blocks are usually contain salts (sodium chloride), but can also contain calcium, iodine, copper, cobalt, iron, selenium and zinc. Since most developing countries are characterized by poor quality roughages which constitute the major portion of rations fed to ruminants (Hadjipanayiotou et al., 1993) and such poor quality roughages and crop residues are the major sources of feed used for feeding ruminant for most part of the year in the semi-arid region, it becomes necessary to supplement these poor quality feeds using multi-mineral blocks. Multi-mineral blocks are generally used to augment the rumen energy and ammonia level of ruminants when the energy and protein needs for maintenance of ruminants is low thus, animals on such diets are on negative energy and nitrogen balance during the dry season thus, (Preston and Leng, 1987; Mancini et al., 1997). Multi-nutrient block has been used for improving the nutritional status of animals (Caper et al., 1986 and Hadjipanayiotou et al., 1975). Many classes of livestock, including swine, poultry, feed lot cattle and dairy cows, mineral supplements are incorporated into concentrate diets, which generally ensure that animals are receiving required minerals (McDowell, 1996). Supplemented cattle on natural grasses in the semi-arid zone of Borno State, Nigeria, lost about 200 – 600g of their body weight per head per day due to one mineral deficiency or the other. As such, when wild grasses and cereal straw are given to ruminant animals alone or forms a high proportion of their diets the primary consideration is to overcome the effect of the resulting nutrient limitation by diet supplementation (Abbator, 1990). Thus, the poor quality of pastures fed to ruminant animals in such region inhibits their performance (Mshelizah et al., 2015).The crude protein content of the grasses drops below 4% during the dry season (Crowler and Chleda, 1977), and are very low in phosphorus and energy (Norman, 1966). The natural grasses, crop residues, animal wastes and to a lesser extent agro-industrial by-products are most widely available low cost feed ingredients for ruminant in Nigeria (Alhassanet al., 1985). Milti-nutrient blocks (MNB) are a commonly used supplement for ruminant (Leng 1984, Sansoucy, 1986; Garcia and Restrepo, 1995). They provide supplemental energy, non protein nitrogen usually from urea, essential minerals and occasionally vitamin – mineral block for rabbit have been made in the past (Perez 1986; Check and Raharjo 1988). For the proper functioning of the animal body in addition to protien, carbohydrate, fat, vitamin and minerals resources required by ruminants include calcium (Ca), magnesium (Mg), phosphorus (P), potassium (K), sodium (Na), sulfur (S), and chloride (Cl) (McDowell, 2003). This experiment evaluates utilization of local feed ingredients to formulate and produce different multi-nutrient blocks which can be locally produced by local farmers for augmenting ruminant feeding regimen, and assess the compactness, hardness, proximate composition, rumen degradation pattern and cost of production of the different of the multi-mineral blocks.

II. Materials And Methods

Experimental site

This experiment was carried out at the University of Maiduguri, Teaching and Research Livestock Farm, Borno State - Nigeria in May 2012. The area is situated on latitude 11°51' North, longitude 30° 05' East and at altitude of 354 m above sea level and within the Sahelian (semi-arid zone) region of West Africa. It is characterized by short rainfall duration (3-4 months) which varies from 300-500 mm, ambient temperatures are highest by April and May and is in the range of 35-40°C while relative humidity ranges from 45-50% reported by Kellou (2005).

Sample collection and presentation

Potash, Salt, Locust bean pulp (daurawa), Fire wood ash, and egg shell were the main locally available ingredients used to produce the five (5) formulated multi-mineral blocks. All ingredients were purchased from the Maiduguri Monday market except egg shell which was obtained from local tea sellers refer to as “maishayi” and fire wood purchased from people that are selling in pickup vans n and was burnt to obtain its ash.

Mixing of feed ingredients

Mixing of the ingredients was done by hand in a 200 L drum cut to a height of 25 cm. Approximately 20 kg of ingredients were mixed per batch in order to get a homogenous mixture. Potash was placed in the drum first followed by wood ash, eggshell, salt and locust bean pulp (daurawa) was added as a binder and the mixture was made homogeneously using strong stick (Kellou, 2005). Each ingredient was introduced only after a homogenous mixture of other ingredients was attained (Mohammed, 2006) and Five (5) formulations (F1 – F5) were produced. The mixing procedure was as outlined by (Aarts et al., 1990). The whole mixture was stirred and mixed properly to obtain a homogenous mixture.

Molding of Multi-mineral blocks

Homogenous mixture of each formulation was placed in wooden container moulds measuring 15x15x10 cm and pressed manually with hand (Allen, 1992). The surface of the wooden mould was covered with polythene sheet to facilitate de-molding and cleaning of the surface. Removal of formed blocks was done immediately from the mold and all blocks were sun dried in the open air under shade for about 24 days. 20kg of each mixed formulation was placed in metal molding blocks to produce 6½, 10, 7½, 8½ and 9½ blocks from F1, F2, F3, F4 and F5. All the 40 blocks plus four pieces of half (½) sized blocks were arranged on a dry concrete slab and sun – dried under a shade for twenty four (24) days.

Drying and packaging of formulated multi-mineral block

During drying, care was taken to ensure that they were not touched by any animal or human being. This method was chosen to encourage the drying condition which prevails in the rural area where ruminant production activities are going on. The blocks were completely dried after 24 days and the blocks were packaged separately, wrapped in polythene bags and stored in moisture free area with proper temperature and adequate ventilation.

Multi-mineral block assessment

All the blocks, F1-F5 were assessed for, compactness (C), Hardness (H) and weight at four days post-drying days after de-molding (Leng, 1992). All blocks were found to contain moisture and are soft on day 4. After twenty (20) days, the compactness of the multi-mineral blocks was assessed by trying to break and crush the block by the use of hand (Amia and Finzi; 1995) and the final test was done after twenty one (21) days and it was determined by three persons independently (Hadjipanayiotou, 1994). Assessing hardness was done by pressing with the thumb in the middle of the block and rated on a scale of: Good (G), Medium (M) and Soft (S), while compactness by the ease with which a block breaks also on a scale of Good (G), Medium (M) and Soft(S). Efforts were geared towards obtaining blocks that set well to ensure safe transportation without breakage (Chemost and Keyoleyi; 1998).

Rumen Degradation Study

The experiment was conducted at the University of Maiduguri livestock teaching and research livestock farm on a healthy bull fitted with permanent rumen cannula of 40mm diameter. The bull was fed cowpea husk ad-libitum as basal diet supplemented with 500g/day of mixture of cotton seed cake + maize bran using ratio 60:40

of energy to protein. Sample from each block were collected and ground to pass through 2.5 mm screen. The nylon bags with mesh size of 45 µ and 140 x 90 mm size were used. 5g of each sample was weighed in replicates and put into the bags. The nylon bags containing the samples were tied at the neck attached to an un-degradable string and tightened very well to avoid loosening during turning in the rumen and removal from the rumen. The incubation periods used were 6, 12, 18, 24, 36, 48 and 72 hours. The bags with the contents were oven dried at 60 °C for 48 hours to constant weight to determine the amount of dry matter loss (Orskov et al., 1980; and McDonald, 1981).

Chemical analysis
The ingredients used in this experiment and the experimental multi-nutrient blocks produced were analyzed for Dry Matter (DM), Crude Protein (CP), Crude Fiber (CF) and Ash using the methods of AOAC (1990) and minerals (Na, Ca, Mg, P and K) using Kruis, (2002) method.

Statistical Analysis
Data collected were subjected to analysis of variance (Steel and Torrie, 1980). Significant differences between means were tested using LSD.

Cost effectiveness of formulation
The cost effectiveness of the formulated multi-mineral blocks was determined by comparing the current market prices of the ingredients used in the formulation at the time of production, and when one $1USD, was equivalent to ₦163 Nigerian Naira.

III. Result And Discussion

Table 1: Proximate composition of feed ingredients used

PARAMETER	POTASH	WOOD ASH	EGGSHELL	SALT	LOCUST BEAN PULP
Dry matter	-	99.90	99.40	-	91.59
Moisture content	-	0.10	0.60	-	8.41
Crude protein	-	1.22	0.61	-	6.65
Crude fiber	-	17.00	6.00	-	11.57
Ether extract	-	1.00	1.00	-	1.80
Nitrogen free extract	-	72.68	88.79	-	67.48
Ash	-	8.00	3.00	-	4.18
Calcium	-	2.40	0.70	-	2.80
Sodium	28.20	0.55	0.33	39.34	0.23
Magnesium	21.00	0.61	0.30	-	9.00
Phosphorus	-	0.23	0.04	-	0.08
Potassium	46.10	4.50	0.40	-	2.75

Table 2: Multi-mineral Block Formulation

Ingredients	F1	F2	F3	F4	F5
Potash	7.00	4.00	5.00	7.00	10.00
Wood ash	6.00	10.00	5.00	9.00	2.00
Egg shell	2.00	1.00	2.00	1.50	2.50
Salt	3.00	2.00	4.00	1.00	2.50
Locust Bean Pulp	2.00	3.00	4.00	1.50	3.00
Total (Kg)	20.00	20.00	20.00	20.00	20.00
Water (Liters)	7.00	7.00	7.50	7.00	6.00

F1 …… F5 = Formulations

Table 2 presents the level of inclusion of each ingredient used to produce the five formulate the five (5) multi-mineral blocks. Inclusion level for potash, wood ash, egg shell, salt and locust bean pulp (daurawa) was 4.00 – 10.00%, 2.00 – 10.00%, 1.00 – 2.50%, 1.00 – 4.00% and 1.50 – 4.00% respectively. Highest inclusion level of the binding agent, locust bean pulp (daurawa) in this experiment was 4.00% which does not agree with (Sansoucy, 2007) who recommended the inclusion of 15% for a binding agent while the level of salt used is lower than 5% reported by (Mohammed et al., 2007) which served as flavor and palatability enhancer (WFE, 2007) and supplies sodium chloride which assist in consolidating the block and control the rate of ingestion

(Chenost and Kayouli, 1997) but in areas where animals suffer from poor water supply, care should be taken in inclusion level of salt in formulations of the multi-mineral block to avoid excessive dehydration. Level of inclusion for Wood ash, Egg shell, and Locust bean pulp (daurawa) is similar to 5% level of inclusion suggested by (Chenost and Kayouli, 1997). Locust bean pulp (daurawa) served as a binder and energy source and was evenly spread during mixing while facilitating uniform hardening of the blocks. This was not in agreement with what was reported by (Sansoucy et al., 1986) who suggested that binding material should be soaked in water for some time before adding to the mixture. The volume water used for the formulation of 20kg multi-mineral block in this experiment ranged from 6.00 – 7.50 Liters, slightly below 8 – 12litres/20kg (40 – 60liters/100kg) reported by (Hadjipanayiotu, 1996) and completely different from the 24 liters/20kg mixture reported by (Mohammed et al., 2007).

Table 3: Physical Characteristics of Blocks (at 24days after production)

Properties	F1	F2	F3	F4	F5
Compactness	M	G	G	M	G
Hardness	S	M	G	M	M
Weight (Kg)	3.20	2.20	3.00	2.30	2.50

G = Good, M= Medium, S= Soft.

Due to the average moisture content of the multi-mineral blocks in this study it took about three (3) weeks, three (3) days (24 days) to completely dry under the sun after molding. This was different from what was reported by (Chenost and Kayouli, 1997) who reported that block will dry and be ready for use after 10 days when dried preferably in the shade as the sun can cause cracking in the mineral blocks. Since mould growth and development is apparent with incomplete drying of blocks (Rajkoma, 1991). Thus, at twenty (20) days of drying, the final blocks on the basis of compactness were Medium (M), Good (M), Good (M), Medium (M) and Good (G) in F1, F2, F3, F4, and F5 respectively while on the basis of hardness, the strength was tested three (3) days after the first twenty one (21) days after sun drying by pressing with hand (thump) at the centre of the block and it was Soft (S), Medium (M), Good (G), Medium (M) and Medium (M) in F1, F2, F3, F4, and F5 respectively as shown in table 3 above. This indicates that the feed ingredient used in each formulation were held together reasonably well by the locust bean pulp (daurawa) which serve as a binder.

Table 4: Proximate Composition of the Multi-mineral Block.

NUTRIENT	F1	F2	F3	F4	F5
Dry matter	93.80	94.90	95.60	95.20	94.60
Moisture	6.20	5.10	4.40	4.80	5.40
Crude protein	1.48	1.31	1.35	1.40	1.31
Crude fiber	14.00	22.00	22.60	11.00	7.00
Ether extract	1.00	1.00	1.00	1.00	1.00
Ash	5.00	4.00	4.20	6.00	13.10
Nitrogen free extract	72.31	66.32	68.25	75.80	72.29

Table 4 gives the result of proximate composition of the multi-mineral blocks which indicates that the dry matter content as 93.80 - 95.60 %DM in all the formulation thus all moisture of the formulated blocks was lost within the 24 days drying period giving them relatively good compactness and hardness which is in concord to 92 – 95 %DM reported by (Mohammed et al., 2007) but higher than 77.4%DM reported by Sansoucy (1986).%CP, %CF, %EE and %Ash ranged from 1.31 – 1.48%, 7.0 – 22.60%, 1.00 - 1.10% and 4.00 – 13.10% respectively. The %CP and %CF range in this experiment different from 10.91% - 1.48 %CP and 11 – 13 %CF range reported by (Onwuka, 1995; Mohammad and Baulube 2004). This variation in proximate composition of the multi-nutrient blocks is attributed to the type and quality of feed ingredient used in the formulations. The nitrogen free extract ranged from 66.32 – 75.80 %NFE slightly above the range of 63.00 – 69.7 %NFE reported by (Ibrahim et al., 2011).

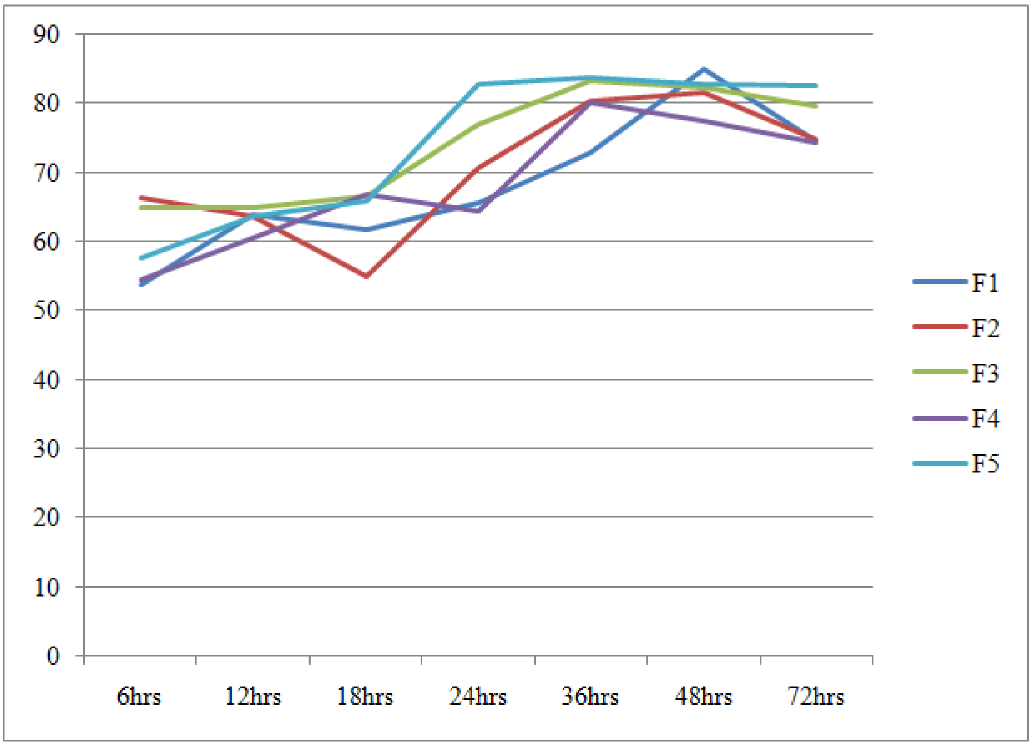
Table 5: Percentage Dry Matter Degradation of the Multi-mineral Blocks.

Time	Formulations					
(Hours)	F1	F2	F3	F4	F5	SEM
6	53.65[c]	66.25[a]	64.85[a]	54.50[c]	57.50[b]	0.6825*
12	63.70[b]	63.67[b]	64.85[a]	60.50[c]	63.50[b]	0.2200*
18	61.67[b]	54.85[c]	66.50[a]	66.85[a]	65.85[a]	0.3215*
24	65.50[d]	70.67[c]	77.00[b]	64.50[d]	82.62[a]	0.5184*
36	72.85[c]	80.50[b]	83.33[a]	80.17[b]	83.67[a]	0.1920*
48	84.85[a]	81.86[c]	82.33[bc]	77.50[d]	82.67[b]	0.1927*
72	74.50[c]	74.85[c]	79.67[b]	74.33[b]	82.50[a]	0.2200*

All superscript (a, b, c, and d) with different alphabet within the same row are significantly ($P < 0.05$) different.

Table 5 shows the degradation pattern of the entire multi-mineral block. Highest dry matter degradation was recorded in F2 (66.25%) and F3 (64.85%) at 6 and 12 hours while at 18 hours there is no significant difference in degradability of F4 and F5. At 24 hours, F5 recorded highest (82.62%) while F1 recorded least (65.50%) with no significant ($P>0.05$) difference between F1 and F4. Mean degradation of 72.85% – 83.67% and77.50% - 84.85% of formulations at 36 and 48 hours respectively, the multi-mineral blocks are said to have stimulated the activities of rumen microbes by increasing the number of the resident microorganisms at 36 and 48 hours. There is no significant difference in degradation between F3 and F5, F1 and F4 at 36 hours. Mean degradation of the multi-mineral blocks ranged from 77.50% – 82.85% at 48 hours of incubation which is above but coherent with 60 %DM degradability at 48 hours recommended by Smith et al., (1988). F1 has the highest (82.85%) percent degradability which could be as a result of level of potash and moderate salt used in the formulation and F4 has the lowest percentage dry matter degradability which could be due to low salt level used in the formulations. Multi-nutrient blocks can be a good source of rumen protein, macro and micro minerals, vitamins, pharmaceuticals and additives to manipulate rumen fermentation Hadjipanayioutou et al., (1993a). Generally, the degradability characteristics at 72 hours of all the multi-mineral blocks are lower than their degradability at 48 hours. Thus, all the formulations can be utilized in ruminant feeding on the basis of their characteristic rumen degradation

Graph of rumen Degradation Mean degradation



Time (Hours)

Table 6: Cost of Ingredients per 20kg Formulation (₦)

Ingredients	F1	F2	F3	F4	F5
Potash	238	119	149	194	298
Wood ash	275	465	211	423	126
Eggshell	71	35	71	53	71
Salt	196	156	313	39	196
Locust bean pulp	76	153	305	115	191
Total Cost(₦)	856	928	1049	824	882

Table 7: Number of Blocks Produced Per Formulation and Cost per Block in ₦ and USD $

	F1	F2	F3	F4	F5
Number of blocks	6 ½	10	7 ½	8 ½	9 ½
Cost/formulation(₦)	856	928	1049	824	882
Cost /block (₦)	132	93	140	97	93
Cost / Block (USD $)	0.80	0.57	0.86	0.60	0.57

$1 US Dollar = ₦ 163.

Table 6 and 7 presents the cost of producing the multi-mineral blocks. The cost effectiveness of the five formulations was estimated when one, $1 USD was equal to ₦163 and at current price of the feed ingredient in the market. The cost of production per 20kg formulation ranged from ₦856 – ₦1, 049. Highest production cost was recorded in F3 with ₦1, 049 ($6.44) which was as a result inclusion level of locust bean pulp (daurawa). The relatively higher cost of production of a mineral block expressed in this experiment was basically due to the quantity and type of ingredients used in the formulation. The cost of production of a 20kg formulation of the multi-mineral blocks in this experiment was generally less than the cost range for multi-nutrient blocks reported by Ibrahim et al., (2011) whose range was ₦2, 522 – ₦2, 835, about ($15.47 - $17.39) and this variation is attributed to the type and quantity of the ingredients used in the production process. Notwithstanding, the cost of producing one multi-mineral block ranged from ₦ 93 – ₦140 per block production is moderate and affordable by local agro-pastoral farmers in the study area.

IV. Conclusion

The findings of this experiment revealed that the rumen requirement of ruminants could be met at a very convenient and affordable way in terms of cost and availability of required minerals in rations fed to animals. Hence, multi-mineral blocks obtained from local feed ingredients have the tendency to enhance the activities of microorganisms by increasing the number of the resident microbes in the rumen for better utilization of low quality roughages especially during dry season, when livestock are often dependent on crop residues which are low in crude protein and high in fiber and as such, peasant agro-pastoralists should augment the basic mineral requirement of their ruminant animals using locally produced multi-mineral blocks from locally available ingredients.

V. Recommendation

Based on the findings of this experiment, the use of formulated multi–mineral block as supplement can provide rumen microorganism requirement for ruminants and could reduce the cost of supplementary feeding of concentrates which are generally more expensive and unaffordable by most agro-pastoral farmers in semi – arid region of North-Eastern part of Nigeria. Thus, use of multi-mineral blocks is strongly recommended in feeding regimen of ruminant animals in regions with poor quality roughages and crop residues. On the basis of quality, least cost of production and high degradability characteristics, F5 can be utilized most preferably.

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